WEST Search History

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DATE: Tuesday, September 28, 2004

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		DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=YES; OP=OR	
☐	L7	(power$ near5 (allocat$3 or assign$4 or apportion$3 or allot$4 or distribut$3)) and (DMT or (discrete adj multi$3 adj tone$)) and ((flag$3 or eliminat$3 or delet$3 or discard$3) near4 (nois$3 near2 (channel$ or bin$)))	1
☐	L6	(power$ near5 (allocat$3 or assign$4)) and (DMT or (discrete adj multi$3 adj tone$)) and (flag$3 near4 nois$3 near2 bin$)	0
☐	L5	(power$ near5 (allocat$3 or assign$4)) and (DMT or (discrete adj multi$3 adj tone$)) and (nois$3 near2 bin$)	9
☐	L4	(power$ near5 (allocat$3 or assign$4)) and (DMT or (discrete adj multi$3 tone$)) and (nois$3 near2 bin$)	14
☐	L3	(power$ near5 (allocat$3 or assign$4)) and (DMT or (discrete adj multi$3 tone$)) and ((eliminat$3 or delet$3 or discard$3) near6 (nois$3 near2 bin$))	0
☐	L2	(power$ near4 (allocat$3 or assign$4)) and (DMT or (discrete adj multi$3 tone$)) and ((eliminat$3 or delet$3 or discard$3) near4 (nois$3 near2 bin$))	0
☐	L1	(power$ near4 (allocat$3 or assign$4)) same (DMT or (discrete adj multi$3 tone$)) same ((eliminat$3 or delet$3 or discard$3) near4 (nois$3 near2 bin$))	0

END OF SEARCH HISTORY

Print Request Result(s)

Printer Name: jef_02a74_gbvaptr
Printer Location: jef__02a74
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- US006134274: Ok
- US006292559: Ok
- US006285708: Ok
- US006275522: Ok

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L5: Entry 3 of 9 File: USPT Jul 9, 2002

DOCUMENT-IDENTIFIER: US 6418161 B1
TITLE: Spread spectrum bit allocation algorithm

Abstract Text (1):
High transmission capacity in a twisted pair signal line, where power is limited by a power spectral-density mask and an aggregate signal power constraint, is obtained by: (1) allocating data to multitone sub-bands according to a lowest marginal power-cost per bit scheme and (2) in an environment where an aggregate power budget remains after all bits have been allocated to all sub-bands with sufficient margins to carry a bit, assigning additional bits to sub-bands with otherwise insufficient power margins to carry a single bit, by frequency-domain-spreading a single bit across several sub-bands at correspondingly reduced power levels, to permit the otherwise unacceptable noise levels to be reduced on average by despreading at the receiving end. Another feature of the invention, applicable in an environment in which multiple interfering channels are employed, provides increased signal throughput by (3) transmitting coherently in a number of multitone sub-bands, identical blocks of data, with the number of multitone sub-bands being equal to a number of interfering channels and multiplying the signal carried by corresponding sub-bands in the separate interfering channels by a different respective vector from an orthonormal basis set so that near-end cross-talk is eliminated upon despreading at the receiving end.

Brief Summary Text (2):
This invention relates to discrete multitone transmission (DMT) of data by digital subscriber loop (DSL) modems and more specifically to the allocation of bits, respectively, to the discrete multitones.

Brief Summary Text (6):
In a DMT modem a transmission frequency band is separated into N sub-bands or frequency bins, each corresponding to one QAM channel. In a non-ideal channel each sub-band has a different capacity as a result of the variation of noise and attenuation with frequency. In addition, external standards impose limits on the aggregate power of a signal (the power applied in all sub-band channels) and a cap on the power as a function of frequency defined by a power spectral density mask.

Brief Summary Text (10):
The above context creates a bit-allocation problem That is, given the constraints, how should bits be allocated among the available QAM channels to provide the highest possible data rates? DSL modems that use DMT modulation concentrate the transmitted information in the frequency sub-bands that have the minimum attenuation and noise. The optimum distribution of transmission power is obtained by distributing the power according to the well-known "water pouring" analogy as described in Robert G. Gallagher, Information Theory and Reliable Communication, John Wiley and Sons, New York, 1968. Such optimal distribution requires a strategy for allocating bits to the sub-bands for the idealized situation where the channel sub-bands approach zero width (.DELTA..function..fwdarw.0). For discrete bits, the applicable metaphor could be described as an ice-cube pouring analogy.

Brief Summary Text (11):

DSL technology was conceived to maximize the throughput on twisted pair copper wiring with attendant background noise, time-variant Far End Cross Talk (FEXT) and Near End Cross Talk (NEXT). To determine the transform characteristic of the channel, the modems negotiate during an initial channel signal-to-noise ratio (SNR) estimation procedure. During the procedure, the transmitter sends a known pseudo noise (PN) signal. The receiver computes the characteristics of the received signal in the form of a ratio N.sub.k /g.sub.k, where g.sub.k is the channel gain (inverse of the attenuation) in frequency band k and N.sub.k is the noise power in the band k. The literature contains many algorithms for determining the power distribution across the full frequency bandwidth for maximum data throughput. As noted above, the optimum approach for non-uniform Gaussian noise channel divided such that each band can be considered an additive white Gaussian noise channel has been proved to be the "water pouring" algorithm of power distribution. In this case, the g.sub.k /N.sub.k Profile is compared to a terrain and the available aggregate power limit to a fixed supply of water poured over the terrain. The depth of the water corresponds to the power spectral density. The water pouring analogy is inappropriate to allocation of power in digital channels intended for transmission of binary data (bits).

Brief Summary Text (12):
According to one method of allocating bits (John A. C. Bingham, Multicarrier Modulation for Data Transmission: An Idea Whose Time Has Come, IEEE Communications Magazine, May 1990, pp5-14), frequency sub-bands or bins are "filled" with data bits one bit at a time. A bit is added to the bin for which the marginal power cost is the lowest. That is, a bit is added to the bin such that transmission in that bin is the least expensive, relative to an additional bit in any other bin, in terms of power needed for the resulting signal constellation to be received at a predefined BER. The filling procedure is followed until the total Power Budget is used up. Since power can only be allocated in discrete amounts corresponding to each bit, the procedure is likened, as mentioned, to an ice-cube filling procedure rather than a water-filling procedure.

Brief Summary Text (15):
It is an object of the invention to provide a method for transmission in a multitone communication system subject to an aggregate signal power constraint together with an algorithm for allocating bits in the system.

Brief Summary Text (21):
Briefly, high transmission capacity in a twisted pair signal line, where power is limited by a power spectral-density mask and an aggregate signal power constraint, is obtained by: (1) allocating data to multitone sub-bands according to a lowest marginal power-cost per bit scheme and (2) in an environment where an aggregate power budget remains after all bits have been allocated to all sub-bands with sufficient margins to carry at least one bit, assigning additional bits to sub-bands with otherwise insufficient power margins to carry a single bit, by frequency-domain-spreading a single bit across several sub-bands at correspondingly reduced power levels, to permit the otherwise unacceptable noise levels to be reduced on average by despreading at the receiving end. In an environment in which multiple interfering channels are employed, signal throughput is increased by (3) forming a number of sub-bands for spreading blocks of data that is equal to a number of interfering channels and multiplying the signal carried by corresponding sub-bands in the separate interfering channels by a different respective vector from an orthonormal basis set so that near-end cross-talk is eliminated upon despreading at the receiving end.

Brief Summary Text (23):
According to the invention bit allocation may be performed to optimize throughput within aggregate power and power spectral density mask limits. Some method, such as the approach identified above with the water pouring analogy, may be used for this bit allocation. The process of bit allocation will be limited either by the mask

limit or the aggregate signal power limit. If after efficient allocation, the total signal power is less than the aggregate power limit, there will usually be unused sub-bands. These unused sub-bands were rejected in the initial bit-allocation process because the available power margin in them was insufficient to transmit a single bit. That is, the channels were identified as unusable because transmitting a single bit was found to exceed the mask limit for the channel. In this case, where the bit allocation process is limited by the mask, the channels with low power margins are used to transmit information by spreading a single block of data (one or more bits) over multiple channels and then despreading them at the receiver.

Brief Summary Text (25):
Discrete Multitone (DMT) modulation serves as a framework to demonstrate the spreading process. An input data stream is segmented into small blocks of bits, and each such block is re-expressed as a complex number. For example, a constellation of 16 possible discrete complex number values can be used to convey 4 bits, since 16 different states are required to represent 4 bits. The resultant array of complex numbers is inverse-Fourier transformed to synthesize a time series, Y(t), that represents a sum of multiple distinct sinusoids. (A complex conjugate array of complex numbers is used as an input to the Inverse Fast Fourier Transform process to assure a real resultant time series.)

Brief Summary Text (31):
According still another embodiment, the invention provides a method for use in a data modulator for allocating bits to data channel frequencies. The method includes the following steps: (1) storing mask power data representing a respective maximum power level for each of the data channel frequencies; (2) storing aggregate power data representing a total amount of signal power to be applied in all of the channel frequencies; (3) allocating bits on a per frequency basis, such that bits are successively allocated until the respective maximum power level is at least substantially reached for each of the channel frequencies and such that each of the bits is allocated to a single respective one of the channel frequencies; and (4) when the aggregate power level is not substantially reached in the step of allocating, further allocating bits to multiples of the channel frequencies for transmission at reduced power rates per channel frequency, to permit further bits to be allocated, until one of the aggregate power limit is substantially reached and the respective maximum power level is reached for each of the data channel frequencies.

Brief Summary Text (32):
According still another embodiment, the invention provides an apparatus that allocates bits for data transmission via a multiple discrete frequencies. The apparatus has tone ordering circuitry, gain scaling circuitry and an inverse discrete Fourier transform modulator. The circuitry in combination allocates initial bits to frequencies on a per frequency basis, such that the initial bits are successively allocated until a maximum power level for each frequency is at least substantially reached, each of the initial bits being unique to a given frequency. The circuitry also calculates a stored total power level for the initial bits allocated to a plurality of transmit frequencies, and if the stored total power level is not exceeded, allocate further bits to frequencies for which no initial bits are allocated, such that each of the further bits is redundantly allocated to more than one of the frequencies.

Detailed Description Text (11):
In a practical implementation of the bin-filling procedure described by Bingham (see Background section), additional constraints such as minimum and maximum number of bits per bin, a power spectrum mask, and a desired set of bit rates may also be considered. Within these constraints and those of the power spectral density mask and the aggregate power limit discussed above, the bin-filling procedure would be followed until the process is halted by any of these limits. Then a second process

of allocation is performed to assign bits to frequency channels that are unallocated due to their not having sufficient power-per-channel to transmit the minimum number of bits. The second procedure determines if these channels can be used within the constraints imposed by the other limits. Thus, a first step applies a first algorithm to allocate bits to each channel within the constraints of aggregate power, maximum power per channel (PSD mask), and the maximum and minimum number of bits per channel. Note that any algorithm that allocates one constellation to each frequency bin would constitute an appropriate first step. A second algorithm is applied to allocate identical blocks of data to multiple channels through spreading as discussed above. The second algorithm would allocate bits to channels if sufficient power margin is available in multiple channels in the aggregate to transmit an additional minimum-sized block of data without exceeding the aggregate power limit. However, it may turn out that transmission of some blocks through spreading is cheaper in terms of power use than transmitting those as allocated during the first allocation procedure. In that case, an approach that employed spread and unspread signaling in an approach that allocated each bit to the channel or channels associated with the least marginal power consumption would be an alternative approach that might lead to more channels being used for spreading than for the two-step approach discussed in detail below. Generally, the most efficient utilization of a channel is to allocate data to channels with the highest SNR, which is the whole idea behind the water-pouring analogy, so the latter approach is not preferred. However, there may be channels with certain kinds of transform characteristics for which such an approach would produce improved performance.

Detailed Description Text (12):
Referring to FIG. 5, a practical bit-allocating algorithm is proposed in a U.S. patent application Ser. No. 08/997,167, filed Dec. 23, 1997, entitled Method and Apparatus for Allocating Data for Transmission Via Discrete Multiple Tones, invented by Sonalkar, et. al., and now U.S. Pat. No. 6,134,274 issued Oct. 17, 2000. According to this procedure, bit allocation is performed with consideration to all practical constraints discussed above. In the method described in the above reference, the entirety of which is incorporated herein by reference, bits are allocated according to the requirements of an aggregate power constraint, a power-spectral density mask limit, and minimum and maximum bits per symbol (e.g, QAM tone).

Detailed Description Text (16):
The bit removal process is implemented to reduce the bit allocation so that the total power required for transmission meets the aggregate power limit. According to a preferred bit removal process, bits are removed sequentially, each bit being selected in turn as the bit, the removal of which, produces the greatest marginal gain in terms of recovered power. The first bit removed then is the bit that cost the most power to transmit. After the bit is deallocated, the corresponding power saved is subtracted from the total power. If the total power constraint is still exceeded after removal of the bit, the next most power-consuming bit is removed. This process is followed iteratively until the power constraint is no longer exceeded. Once the aggregate power limit is met, the first procedure is completed and no second procedure follows.

Detailed Description Text (20):
Next, at step S3, an array is calculated containing the power required to transmit one bit for all bins that were not allocated in the procedure of FIG. 5. The array indicates the bin by a frequency pointer (a label), the number of bits already assigned to that bin, and the power requirement to add another bit to that bin. Now, the power required to transmit b.sub.k bits is given by: ##EQU1##

Detailed Description Text (22):
b.sub.k is the number of bits carried in frequency bin k, E.sub.k is the power required in bin k to transmit the b.sub.k bits, g.sub.k /N.sub.k is the measured

gain to noise ratio in bin k, and G.sub.c is the coding gain. K is given by: ##EQU2##

Detailed Description Text (26):
Thus in calculating the power bin array, the number of bits already allocated to each of the bins is taken into account in calculating the power requirement. So the power requirement calculation is a marginal power required to add another bit to the bin. In calculating the amount of power required, if the calculated power would exceed the PSD mask limit for that bin, a very large number is used for the energy requirement so that when the array is sorted in order of increasing power, these bins with low PSD limits end up at the bottom of the sorted list.

Detailed Description Text (29):
In step S5, the residual power (difference between aggregate power requirement and the power required to transmit all assigned bits) is calculated from all assigned bins using equation (1). Next in step 9, the total power to transmit one bit in the adjacent m bins is calculated. Note that the m adjacent bins are adjacent in terms of the index value corresponding to the power sorting done in step S4, not the arrangement in terms of frequency.

Detailed Description Text (37):
As mentioned the bit allocation process is not limited by the aggregate power constraint that applies, but by the second limit on the power in each band, the power spectral density mask. This occurs may occur in long lines and/or noisy environments. The mask prevents assigning any further bits to unoccupied bands because the attenuation and noise would require too much power in any of the remaining bands.

Detailed Description Text (40):
Although according to the embodiments described above, power is distributed equally to the bins across which a single block is transmitted, it is clear from the description that other possibilities exist. For example, the m bins could be assigned power on a pro rata basis according to the noise-power/gain ratio corresponding to each bin. Thus, the bin corresponding to the lowest noise-power/gain ratio could carry the greatest share of the power. Bins could also be allocated different power levels according to the power margin available below the PSD mask limit.

Detailed Description Text (87):
44. Method And Apparatus For Allocating Data Via Discrete Multiple Tones, U.S. patent application Ser. No. 08/997,167, filed Dec. 23, 1997, and issued as U.S. Pat. No. 6,134,274 on Oct. 17, 2000;

Detailed Description Text (88):
45. Method And Apparatus For Reducing Near-End Cross Talk In Discrete Multi-Tone Modulators/Demodulators, U.S. patent application Ser. No. 08/997,176, filed Dec. 31, 1997.

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L7: Entry 1 of 1 File: USPT Sep 24, 2002

DOCUMENT-IDENTIFIER: US 6456657 B1
TITLE: Frequency division multiplexed transmission of sub-band signals

Brief Summary Text (7):
QAM systems tend to operate at the higher frequency bands of the channel, which is particularly undesirable for two-wire subscriber loops where attenuation and cross-talk are worse at the higher frequencies. It has been proposed, therefore, to use frequency division modulation (FDM) to divide the transmission system into a set of frequency-indexed sub-channels. The input data is partitioned into temporal blocks, each of which is independently modulated and transmitted in a respective one of the sub-channels. One such system, known as discrete multi-tone transmission (DMT), is disclosed in U.S. Pat. No. 5,479,447 issued December 1995 and in an article entitled "Performance Evaluation of a Fast Computation Algorithm for the DMT in High-Speed Subscriber Loop", IEEE Journal on Selected Areas in Communications, Vol. 13, No. 9, December 1995 by I. Lee et al. Specifically, U.S. Pat. No. 5,479,447 discloses a method and apparatus for adaptive, variable bandwidth, high-speed data transmission of a multi-carrier signal over a digital subscriber loop. The data to be transmitted is divided into multiple data streams which are used to modulate multiple carriers. These modulated carriers are converted to a single high speed signal by means of IFFT (Inverse Fast Fourier Transform) before transmission. At the receiver, Fast Fourier Transform (FFT) is used to split the received signal into modulated carriers which are demodulated to obtain the original multiple data streams.

Brief Summary Text (8):
Such a DMT system is not entirely satisfactory for use in two-wire subscriber loops which are very susceptible to noise and other sources of degradation which could result in one or more sub-channels being lost. If only one sub-channel fails, perhaps because of transmission path noise, the total signal is corrupted and either lost or, if error detection is employed, may be retransmitted. It has been proposed to remedy this problem by adaptively eliminating noisy sub-channels, but to do so would involve very complex circuitry.

Brief Summary Text (9):
A further problem with DMT systems is poor separation between sub-channels. In U.S. Pat. No. 5,497,398 issued March 1996, M. A. Tzannes and M. C. Tzannes proposed ameliorating the problem of degradation due to sub-channel loss, and obtaining superior burst noise immunity, by replacing the Fast Fourier Transform with a lapped transform, thereby increasing the difference between the main lobe and side lobes of the filter response in each sub-channel. The lapped transform may comprise wavelets, as disclosed by M. A. Tzannes, M. C. Tzannes and H. L. Resnikoff in an article "The DWMT: A Multicarrier Transceiver for ADSL using M-band Wavelets", ANSI Standard Committee T1E1.4 Contribution 93-067, March 1993 and by S. D. Sandberg, M. A. Tzannes in an article "Overlapped Discrete Multitone Modulation for High Speed Copper Wire Communications", IEEE Journal on Selected Areas in Comm., Vol. 13, No. 9, pp. 1571-1585, Dec. 1995, such systems being referred to as "Discrete Wavelet Multitone (DWNIT).

Brief Summary Text (10):

A disadvantage of both DMT and DWMT systems is that they typically use a large number of sub-channels, for example 256 or 512, which leads to complex, costly equipment and equalization and synchronization difficulties. These difficulties are exacerbated if, to take advantage of the better characteristics of the two-wire subscriber loop at lower frequencies, the number of bits transmitted at the lower frequencies is increased and the number of bits transmitted at the higher frequencies reduced correspondingly.

Detailed Description Text (22):
Simplified versions of the input signal S.sub.i, sub-band wavelet signals y.sub.0, y.sub.1, y.sub.2 and y.sub.3, sub-band wavelet modulated carriers y'.sub.0, y'.sub.1 and y'.sub.2, and the transmitted signal S.sub.o, which are similar in the encoders of FIGS. 2 and 5, are shown in FIGS. 8-10. FIG. 8 shows the simplified input signal S.sub.o, (which is not the same as that illustrated in FIG. 7A). FIGS. 9A, 9B, 9C and 9D illustrate the sub-band wavelet signals y.sub.o, y.sub.1, y.sub.2 and y.sub.3 obtained by DWT processing of the input signal S.sub.i. FIGS. 10A, 10B and 10C illustrate the corresponding modulated carrier signals y'.sub.0, y'.sub.1 and y'.sub.2 obtained by modulating the carrier signals f.sub.0, f.sub.1, and f.sub.2 with the sub-band wavelet signals y.sub.0, y.sub.1 and y.sub.2, respectively. Because the waveform of the simplified input signal is so smooth, the wavelet signal y.sub.2 is interpolated by a factor of 2 only, and the wavelet signal y.sub.0 and y.sub.1 by a factor of 4 only. This is, of course, for illustration only; in practice the interpolator may typically range from 1:8 to 1:24. FIG. 11 shows the encoded signal S.sub.o and FIG. 12 shows its frequency spectrum which comprises the spectrum components of y'.sub.0, y'.sub.1 and y'.sub.2 centered at frequencies of 1000 Hertz, 3000 Hertz and 5000 Hertz, respectively. for a message rate of 750 Hertz. The asymmetric distribution of transmission power between the lower and high frequency carriers should be noted. It should be appreciated that these simplified signals are for illustration only and that real signals would be much more complex.

Other Reference Publication (6):
Lee, Inkyu; Chow, Jacky S.; and Cioffi, John M.: "Performance Evaluation of a Fast Computation Algorithm for the DMT in High-Speed Subscriber Loop", IEEE Journal on Selected Areas in Communications, vol. 13, No. 9, Dec. 1995.